Influence of Stubby-Root Nematode On Growth of Southern Pine Seedlings

BY
JOHN L. RUEHLE

Abstract. Seedlings of *Pinus elliottii* var. *elliottii* Engelm., *P. palustris* Mill., and *P. taeda* L. were severely stunted when grown in the greenhouse in soil infested with the stubby-root nematode, *Trichodorus christiei* Allen. Root and shoot weights of all three pine species grown in infested soil were significantly less than those of seedlings in noninfested soil. Plants grown in infested soil also had significantly less total root surface.

Additional key words. *Trichodorus christiei*, *Pinus* sp., nematode parasitism, host-parasite relation.

THE STUBBY-ROOT nematode, *Trichodorus christiei* Allen, is a damaging parasite of annual crops (Alhassan and Hollis 1966, Christie and Perry 1951, Hoff and Mai 1962, Rohde and Jenkins 1957, Russell and Perry 1966) and of certain perennial crops (Standifer and Perry 1960, Zuckerman 1962). It is also associated with forest trees in southern woodlands (Ruehle 1962, 1964). Hopper (1958) reported *Trichodorus* spp. in 19 of 35 southern pine tree nurseries. In a survey of southern forest nurseries,[1] *T. christiei* was found associated with slash pine (*Pinus elliottii* var. *elliottii* Engelm.) and loblolly pine (*P. taeda* L.) in 5 of 16 nurseries sampled.

I have previously demonstrated that *T. christiei* is parasitic on southern pines (Ruehle 1966). The present study was designed to examine quantitative relationships between attack by this nematode and the growth of longleaf (*Pinus palustris* Mill.), slash, and loblolly pine seedlings.

Methods and Materials

Stubby-root nematodes were obtained from a previous host-range study on pines (Ruehle 1966). They were extracted from the soil by an elutriator-pan technique (Oostenbrink 1960). Residues from the elutriator (apparatus for controlled soil washing) were placed on cotton filters supported on wire screens in water-filled pans. After 24 hr, water suspensions of the nematodes from all pans were pooled and mixed. The nematodes were divided with a burette into water suspensions of 500 and 5,000 nematodes each.

Fine sandy loam soil potted in 20-cm clay pots was steam-pasteurized at 80° C for 1 hr. A suspension containing either 500 or 5,000 nematodes was poured on the soil surface of each pot except the controls and covered an inch deep with steamed soil. The water through which the nematodes had settled in the pans was added to the control pots, 50 ml/pot. Each pine species was sown in a group of 15 pots composed of 3 treatments replicated 5 times. After emergence, the seedlings were thinned to five plants per pot.

The 45 pots were watered as required. Greenhouse temperatures ranged from 20° to 32° C.

[1] Ruehle, J. L. Unpublished data, 1966.

The author is Plant Nematologist, Forestry Sciences Laboratory, Southeastern Forest Expt Sta., Forest Service, U. S. Dept. Agric., Athens, Georgia. Manuscript received Oct. 7, 1968.

Heights of slash and loblolly seedlings were measured after 6 months. Longleaf was not measured because seedlings of this age are nearly stemless.

After 9 months the seedlings were removed from the pots, and the soil gently shaken from the roots. The five seedlings in each pot were root bound, and difficult to separate without causing root damage. Therefore, the roots were left entangled, rinsed, and drained for 30 minutes. The soil from each pot was thoroughly mixed, and a 100 cc sample assayed for nematodes by a centrifugal-flotation technique (Jenkins 1964).

The green tops and roots from each pot were weighed. A root titration technique (Anderson 1963) was used to estimate total surface of the combined root systems from each pot.

Results and Discussion

The roots of all three pine species growing in *Trichodorus*-infested soil were severely stunted and lacked fine feeder roots (Fig. 1). Mycorrhizae were well developed in noninoculated controls but were few or lacking in soil originally infested with 5,000 nematodes. Hollis (1963), in proposing an action theory of plant-parasitic nematodes on their hosts, has separated pathogenic action from parasitic action. *T. christiei* is, therefore, interpreted as having a parasitic action on pine roots because it causes only a reduction of root and top growth. The lack of necrosis and growth malformation indicates that this relationship is one of balanced parasitism.

Top growth of seedlings in infested soil was less than that of seedlings grown in nematode-free soil. Seedlings of all three species in infested soil had fewer needles than did those in nematode-free soil but were comparably green. A comparison of seedling heights of slash and loblolly after 6 months showed that stubby-root nematodes caused a significant reduction in growth, apparently greater in slash than in loblolly seedlings (Table 1).

TABLE 1. Influence of stubby-root nematodes on height growth of slash and loblolly seedlings after 6 months.

Initial number of nematodes	Mean height (n = 25)[1]	
	Slash	Loblolly
	Cm	*Cm*
Control	23.3[a]	16.4[a]
500	19.0[b]	15.1[ab]
5,000	16.6[b]	14.4[b]

[1] Mean heights not followed by the same letter are significantly different at the 5-percent level by the Duncan multiple-range test.

For all three species, there was a significant reduction ($P \leq .05$) in top and root weights of the seedlings growing in soil originally infested with 5,000 nematodes (Fig. 2). The growth of seedlings in soil originally infested with 500 nematodes was not as greatly reduced (only the tops of slash pine seedlings growing in infested soil weighed significantly less than those of the controls); however, total fresh weights of both slash and loblolly seedlings grown in soil with either concentration of nematodes were significantly less ($P \leq .05$) than those of the controls. Because these three species differ so markedly in growth characteristics, particularly in top/root ratios (Fig. 2), no comparison was made of nematode effects among species.

There was a marked reduction in total root surface, as estimated with root titration values (Table 2), for all three species growing in infested soil. The comparison of total absorbing surface is probably a better measure of stubby-root nematode damage than is the comparison of fresh weight of roots. Weight comparisons do not differentiate between large, heavy roots with limited absorbing surface and smaller, fibrous roots with much larger absorbing surface (Anderson 1963). This nematode feeds primarily at or near the tips of fine roots, preventing root elongation of agronomic plants (Apt and Koike 1962, Rohde and Jenkins 1957, Standifer and Perry 1960); and the

injury to pine is obviously a result of root-tip feeding, which causes a reduction of the fine root system without obvious abnormalities. A comparison of the two root measurements indicates that the effect of this nematode is greater on root surface than on root weight (Table 1, Fig. 2). Longleaf, loblolly, and slash seedlings in soil inoculated with 5,000 nematodes had 64, 62, and 66 percent less root surface, respectively, when compared with the controls, but only

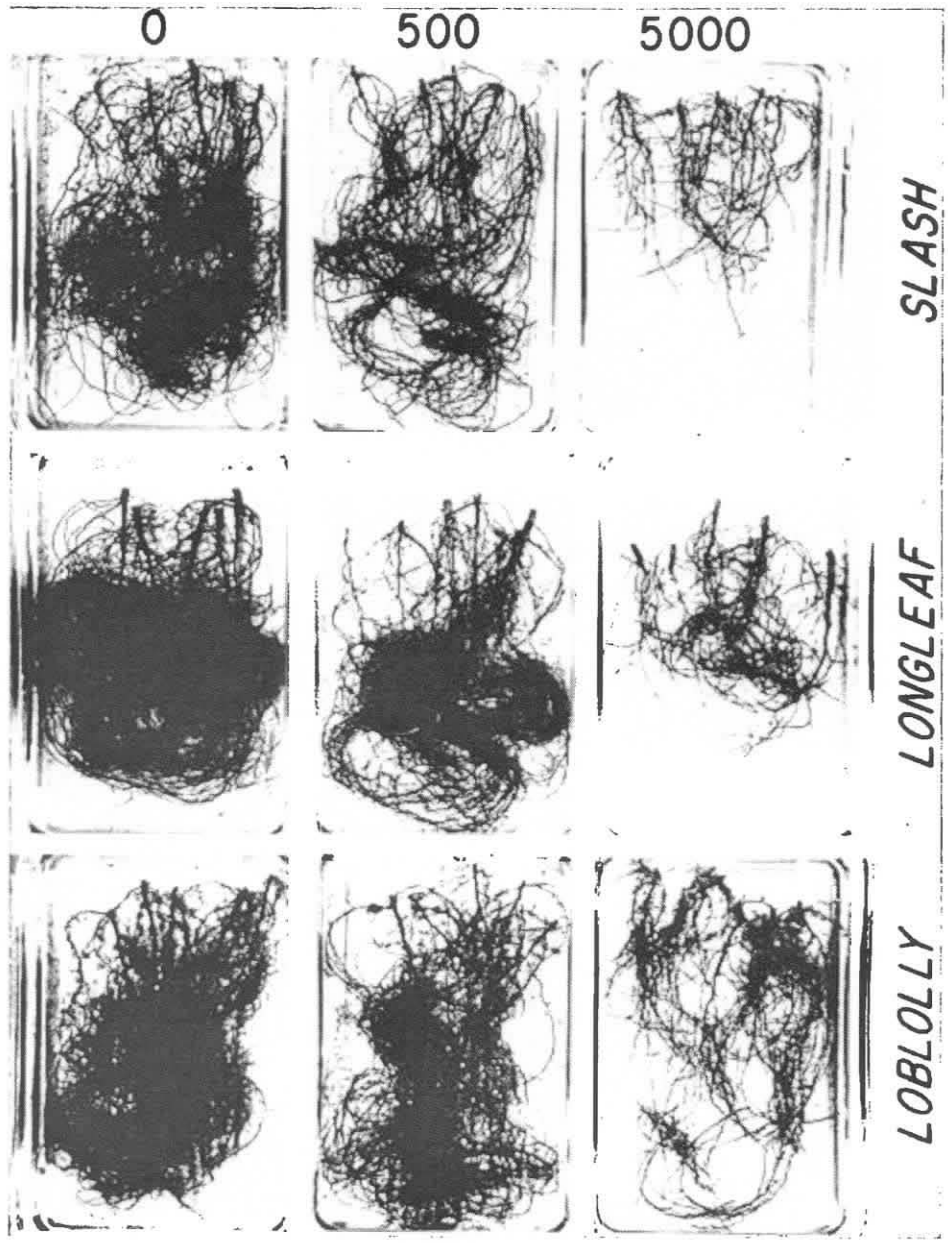

FIGURE 1. *Effect of stubby-root nematodes on roots of 9-month-old pine seedlings. Each dish contains root systems of five seedlings from a sample pot.*

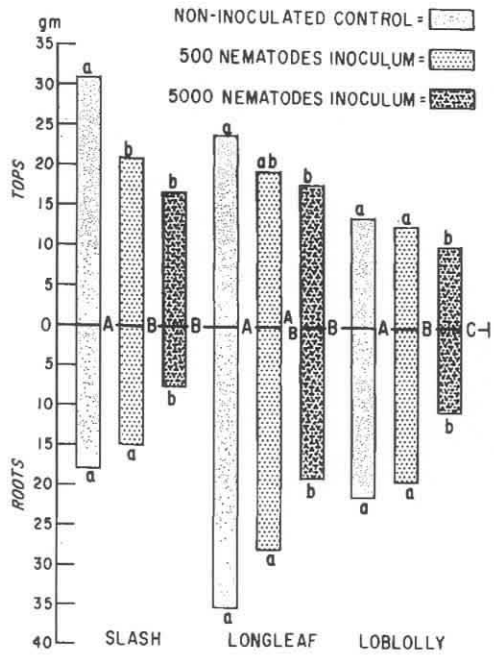

FIGURE 2. *Effect of stubby-root nematodes on fresh weight of pine seedlings after 9 months. Bars represent the mean of 5 replicates, each with 5 seedlings. Capital letters along the zero line designate significant differences in total fresh weight among treatments within species; unlike letters indicate differences significant at the 5-percent level by the Duncan multiple-range test. Similarly, the lower case letters indicate differences for top and root weight.*

46, 51, and 58 percent less weight.

The numbers of nematodes in the various pots after 9 months (Table 2) are inversely related to root development (Table 2, Fig. 2), as also reported with *Trichodorus christiei* on cotton seedlings by Alhassan and Hollis (1966).

The presence of stubby-root nematodes in the controls (in one of five longleaf and three of five loblolly replicates) was probably due to splashing water.

The high numbers of stubby-root nematodes associated with the most severely stunted seedlings rarely occur in forest nursery and plantation soils. It is not uncommon for population levels in greenhouse tests to be much higher than normally found in the field (McGlohon *et al.* 1961, Thomason and Sher 1957). Under field conditions where moisture supply, soil fertility, and temperature are often unfavorable for plant growth, lower numbers of nematodes may be sufficient to cause injury.

TABLE 2. Increase of stubby-root nematodes and their effect on total absorbing surface of pine seedling roots.

Seedling species	Nematodes/pot		Root titration value[2]
	Initial	After 9 months[1]	
	No.	*No.*	*Ml*
Slash	control	0	118[a]
	500	2,200 ± 900	83[b]
	5,000	18,000 ± 5,000	40[c]
Longleaf	control	5 ± 12	173[a]
	500	900 ± 500	129[a]
	5,000	7,500 ± 1,900	62[b]
Loblolly	control	200 ± 300	131[a]
	500	700 ± 200	107[b]
	5,000	19,000 ± 6,200	49[c]

[1] Mean ± standard deviation of 5 replicates based on extraction of 100 cc soil.

[2] Mean of 5 replicates, each with 5 seedlings. Within species, values not followed by the same letter are significantly different at the 5-percent level by the Duncan multiple-range test.

Literature Cited

ALHASSAN, S. A., and J. P. HOLLIS. 1966. Parasitism of *Trichodorus christiei* on cotton seedlings. Phytopathology 56:573–574.

ANDERSON, H. W. 1963. Soil fumigation increases the root growth of forest nursery seedlings. Down to Earth 19:6–8.

APT, W. J., and H. KOIKE. 1962. Influence of the stubby-root nematode on growth of sugarcane in Hawaii. Phytopathology 52:963–964.

CHRISTIE, J. R., and V. G. PERRY. 1951. A root disease of plants caused by a nematode of the genus *Trichodorus*. Science 113:491–493.

HOFF, J. K., and W. F. MAI. 1962. Pathogenicity of the stubby-root nematode to onion. U. S. Dept. Agric. Plant Dis. Reptr. 46:24–25.

HOLLIS, J. P. 1963. Action of plant-parasitic nematodes on their hosts. Nematologica 9:475–494.

HOPPER, B. E. 1958. Plant-parasitic nematodes in the soils of southern forest nurseries. U. S. Dept. Agric. Plant Dis. Reptr. 42:308–314.

JENKINS, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. U. S. Dept. Agric. Plant Dis. Reptr. 48:692.

MCGLOHON, N. E., J. N. SASSER, and R. T. SHERWOOD. 1961. Investigations of plant-parasitic nematodes associated with forage crops in North Carolina. N. C. Agric. Expt. Sta. Tech. Bull. 148, 39 pp.

OOSTENBRINK, M. 1960. Estimating nematode populations by some selected methods, pp. 85–102. *In* J. N. Sasser and W. R. Jenkins, eds., Nematology—Fundamentals and Recent Advances. 480 pp. Univ. N. C. Press, Chapel Hill.

ROHDE, R. A., and W. R. JENKINS. 1957. Host range of a species of *Trichodorus* and its host-parasite relationships on tomato. Phytopathology 47:295–298.

RUEHLE, J. L. 1962. Plant-parasitic nematodes associated with shortleaf pine showing symptoms of littleleaf. U. S. Dept. Agric. Plant Dis. Reptr. 46:710–711.

———. 1964. Plant-parasitic nematodes associated with pine species in southern forests. U. S Dept. Agric. Plant Dis. Reptr. 48:60–61.

———. 1966. Nematodes parasitic on forest trees. I. Reproduction of ectoparasites on pines Nematologica 12:443–447.

RUSSELL, C. C., and V. G. Perry. 1966. Parasitic habit of *Trichodorus christiei* on wheat. Phytopathology 56:357–358.

STANDIFER, MARIE S., and V. G. PERRY. 1960. Some effects of sting and stubby-root nematodes on grapefruit roots. Phytopathology 50:152–156.

THOMASON, I. J., and S. A. SHER. 1957. Influences of the stubby-root nematode on growth of alfalfa Phytopathology 47:159–161.

ZUCKERMAN, B. M. 1962. Parasitism and pathogenesis of the cultivated highbush blueberry by the stubby-root nematode. Phytopathology 52 1017–1019.